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PLACES TV-TRACK, IONOSONDE, AND MAGNETOMETER OPERATIONS

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This report describes the TV tracking system, the slow-scan TV system, the KEL ionosonde, and the magnetometer that were operated in support of the PLACES experiment conducted at Eglin AFB, Florida in December 1980. A procedure for determining the proper launch time and aim point for both the beacon rockets and the probe rocket was developed after post-mission analysis of the first two releases. This procedure contributed to a successful beacon occultation for Event IRIS, and a successful probe penetration for Event JAN.

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I INTRODUCTION

The PLACES experiment, conducted at Eglin AFB, Florida in December 1980 was designed to test the effects on radio signals that are propagated through field-aligned electron-density enhancements (striations). Specifically, the test was designed to validate the prediction of serious degradation caused to phase-coherent systems by striation-induced phase effects. It was intended that these effects be demonstrated on signals from the LES 8/9 satellites. The striations were produced by 48-kg barium payloads released at approximately 185 km in the F-region of the ionosphere on four separate days. In addition to the satellite measurements made by an aircraft vectored to the proper location by a ground controller, there was a rocket-borne beacon transmission experiment, an in-situ probe experiment, and ground support instrumentation.

The primary data for aiming both the beacon rockets and the probe rocket and for aircraft vectoring were obtained from TV tracking of the barium cloud from two stations (A-15 and D-3). To coordinate TV aiming points and to aid in determining launch times for both beacon and probe rockets, a slow-scan TV system was constructed and operated with TV displays at CCF and at A-15. These displays provided images of the barium cloud seen by both TV tracking cameras. This report addresses operation of the TV tracking system, the slow-scan TV system, the KEL ionosonde, and the magnetometer.

II EQUIPMENT SETUP IN FLORIDA

SRI International personnel and equipment from Menlo Park, California arrived at Eglin, Florida by 10 November 1980 as scheduled. Setup of the TV tracking and the slow-scan TV systems commenced shortly after. Considerable difficulties were encountered with the data lines connecting A-15 with CCF, C-6, and D-3. Most of the problems, however, were resolved by 2 December 1980, the first scheduled launch day.

The TV tracking system was completely operational by the first launch day, although for Event GAIL a noisy data line between D-3 and A-15 caused bad pointing angles to be passed occasionally to the Sandia computer. This problem was corrected for subsequent launches by lowering the baud rate for data transmission between D-3 and A-15 from 1200 baud to 300 baud. On the second event, HOPE, the graphic board at D-3, which was used to provide the electronic boresight, failed shortly before launch. A boresight was manually located on the TV monitor and calibrated against the sun and a few known reference points. At the conclusion of the event the boresight was checked against the stars and both elevation and azimuth at the D-3 site were found to be in error by approximately two degrees. Drift in the TV monitor was believed to be the primary cause of this error.

The TV tracking systems at D-3 and A-15 were completely recalibrated following HOPE, and no other problems were encountered for Event IRIS and JAN. Calibration checks for the last two events indicate that the TV-track pointing angles at both D-3 and A-15 were accurate to within a few tenths of a degree.

The slow-scan TV system was also fully operational on 2 December, but because of data line problems, slow-scan displays were provided only to A-15 and CCF. When the data line problems between A-15 and C-6 were corrected toward the end of the PLACES experiment the slow-scan system was not installed at C-6 as planned. The reasons for this were that the

slow-scan displays were not required for the particular operating mode used for the FPS-85, and that the system intended for C-6 was being used at A-15 to provide D-3 cloud images needed for cloud tracking and launch decisions.

The KEL ionosonde was shipped directly to Florida from Australia without the receiver. The receiver was hand carried to Florida by Mr. Terry Kelly and Mr. Derrick Horton of KEL Aerospace, who arrived on 29 November 1980. The ionosonde was checked out and the antenna was installed by the two KEL engineers. The ionosonde was fully operational by 1 December 1980.

The magnetometer was operational by 1 December 1981 and was continuously operated to monitor magnetic field variations. Magnetic activity was visually monitored by means of the meters on the magnetometer and periodic strip chart recordings. Continuous recording of the magnetic field variations was not done, due to the excessive speed of the chart recorder. From meter readings and occasional recordings we estimate that the magnetic activity was quiet during the entire PLACES experiment.

III RESULTS

A. TV Tracking

Tracking data from D-3 and A-15 were provided to the Sandia computer and recorded at approximately 3-Hz rate. Digital tapes for each of the four events contain time of day and pointing angles from the two sites. These data were recorded for documentation and possible post-mission analysis. In particular, the tracking data would be useful for designing and testing barium cloud tracking algorithms.

Video information from each site was also recorded for each of the releases. These video tapes were extremely usefor for post-mission critique. The quality of the video was sufficient to show the development of the barium cloud, and for Event JAN the flashing beacon aboard the probe rocket can be seen on the A-15 video tapel.

With the experience gained from GAIL and HOPE, the following procedure evolved to provide good tracking data:

(1) After tracking has stabilized (about 10 to 15 s after release), a two-station solution is used to determine the release height.

(2) After calculating the release height, the station providing the "best" track is used for cloud location (single station solution).

(3) After the initial release, the TV track operator should estimate the location of the ion cloud and move slowly to its projected position. When the cloud is sufficiently developed to permit an assessment of the point tracked, a correction should be made if necessary. If a significant change is required, the tracking filter should be reinitialized.

B. Slow-Scan TV

The slow-scan TV system consisted of four separate units for each of four sites--CCF, C-6, A-15, and D-3. The units at CCF and C-6 were two-hannel, receive only, while the unit at D-3 was provided with a

single-channel transmit capability. The A-15 unit had a single-channel receive and a single-channel transmit capability, but a timing problem prevented the A-15 slow-scan unit from operating in both transmit and receive modes. Hence, it was necessary to use the C-6 unit to receive slow-scan transmissions from D-3.

Each channel of the slow-scan TV system consisted of a CROMENCO SCC (single-card computer) system. The SCC is a Z-80, S-100 bus microprocessor. Each was interfaced with a Digital Video Systems CAT-100/C (computer assisted television system). With this configuration a television frame could be digitized at a 21-MHz rate. The resolution of each frame was 240 X 256 pixels (4-bits per pixel), but only 240 X 128 pixels were transmitted, in order to maintain a reasonable update time for each frame. With the 1200-baud telephone line used, a complete television frame was transmitted in approximately 70 s.

The four-bit quantization of each pixel provides a 16-level gray scale. To enhance the digitized image, the digitization range was adjusted to provide the best picture. This feature was added after Event GAIL and produced a significant improvement in picture quality.

C. Ionogram

Verbal readings of the F-layer critical frequency were provided on request to Dr. Victor Gonzalez at the FPS-85. Ionograms were also recorded every 20 s for Event GAIL. These ionograms showed returns from the barium ion cloud starting at approximately 2305 UT and ending at approximately 0150 UT. Because of interference to another experiment operating at A-15, the ionosonde was not operated during Event HOPE except when necessary to provide a reading of f_oF_2. The ionosonde was operated on a 15-minute schedule for Events IRIS and JAN, but because of a film jam, ionograms are not available for these events.

D. Magnetometer

Permanent records were not kept of the magnetometer output since it was used only as a real-time indicator of magnetic conditions.

IV CONCLUSIONS AND RECOMMENDATIONS

Considerable difficulties were encountered in tracking the barium ion cloud and in determining the proper launch time and aim point for both beacon and probe rockets. Most of the difficulties stemmed from the requirement that the beacon occult, or that the probe penetrate, the highest-density and most structured part of the barium ion cloud. To accomplish this in the limited optical window available, both the time and location of the properly developed ion cloud must be predicted in real time based on optical information. The slow-scan images were valuable for providing two near simultaneous views of the barium cloud at one site to enable decisions on launch time and TV tracking points to be made.

The following recommendations are made for future PLACES-type experiments:

(1) The single-station solution (adopted partly because of the experience gained from the STRESS experiment) proved to be a viable procedure and is recommended for any future PLACES-type beacon or probe launches.

(2) The tracking algorithm used during PLACES was unduly restrictive in that it required a long period of "good" tracking data. Other types of tracking algorithms should be investigated based on the experience gained during PLACES. Candidate algorithms could be assessed by use of the actual PLACES digital tracking data.

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